European Journal of Geography

The publication of the European Journal of Geography (EJG) is based on the European Association of Geographers' goal to make European Geography a worldwide reference and standard. Thus, the scope of the EJG is to publish original and innovative papers that will substantially improve, in a theoretical, conceptual, or empirical way the quality of research, learning, teaching, and applying geography, as well as in promoting the significance of geography as a discipline. Submissions are encouraged to have a European dimension. The European Journal of Geography is a peer-reviewed open access journal and is published quarterly.

Received: 06/08/2024

Revised: 07/11/2024

Revised: 16/12/2024

Accepted: 17/12/2024

Published: 18/12/2024

Academic Editor:
Dr. Alexandros Bartzokas-Tsiompras

DOI: 10.48088/ejg.p.fay.15.4.305.318

ISSN: 1792-1341

Research Article

A Survey to Capture the Mobility Behavior of Residents in the Republic of Cyprus

Philip Fayad[1]✉, Phaedon Kyriakidis[1], Constantinos Tsioutis[2] & Dimitris Kavroudakis[3]

[1] Cyprus University of Technology, Department of Civil Engineering and Geomatics, Limassol, Cyprus
[2] European University of Cyprus, School of Medicine, Nicosia, Cyprus
[3] University of the Aegean, Department of Geography, Mytilene, Greece

✉ Correspondence: pk.fayad@edu.cut.ac.cy

Abstract: In today's highly mobile world, people of all age groups constantly move between various locations, such as their homes, grocery stores, schools, and workplaces, reflecting the dynamic nature of modern society. The recent COVID-19 pandemic has underscored the profound impact of human mobility on the rapid spread of the virus within and between urban areas. The current study investigates the daily mobility behaviors of residents of the Republic of Cyprus. Through a comprehensive survey, the research documents travel patterns, commuting habits, and transportation preferences across various age groups and districts of Cyprus. With a total of 787 responses from all districts of Cyprus, data was collected through an online survey from 20/11/2023 to 20/02/2024. Data analysis includes descriptive methods and statistical modeling techniques in order to provide insights into the patterns of human mobility. Key findings include insights into travel distances, frequencies, duration and means of transportation, and timelines of mobility activities during typical workdays, as well as during weekends.

Keywords: survey; mobility behavior; urban mobility patterns; spatiotemporal transportation; Cyprus

Highlights:

- 787 individuals responded to the online questionnaire.
- Human mobility timelines are extracted, depicting the typical location and activity of individuals every two hours during workdays, as well as during weekends.
- Across all age groups, people generally tend to travel short distances up to around 10 kilometers.
- Car usage is the predominant mode of transportation across all categories. Walking is the second most preferred mode and bus rides rank third.

1. Introduction

Nowadays**,** mobility research spans various domains and serves as a foundational framework for numerous applications. In transportation planning, these studies are indispensable for optimizing routes, improving public transit networks, and mitigating traffic congestion. Urban studies utilize mobility research to inform decisions on city design, land use, and resource allocation, fostering the creation of sustainable urban environments. The impact of mobility on social behavior and community dynamics is explored in social sciences, while environmental assessments leverage mobility data for designing eco-friendly transportation systems. Businesses draw on mobility insights for market research, strategic decision-making, and marketing strategies. Mobility studies also play a crucial role in disaster response, smart city development, tourism management, and security and law enforcement, addressing complex challenges and advancing interdisciplinary solutions. Furthermore, human mobility models are versatile and find applications across diverse domains such as traffic forecasting (Kitamura et al., 2000; Litmeyer et al., 2023), activity-based modeling (Bhat & Koppelman, 1999), and transportation networks design (Ukkusuri et al., 2007). Additionally, these models are employed in scenarios requiring simplified representations of residential mobility (Vorel, 2023), virus spreading and epidemic evolution (Kleinberg, 2007; Nicolaides et al., 2012), evaluating human exposure to air pollutants (Hanson, 2005), and simulating mobile networks of wireless devices (Rhee et al., 2008).

Epidemiology benefits from insights into human mobility patterns (Lessani et al., 2023) to model and predict the spread of diseases, contributing to effective public health strategies (Kyriakidis et al., 2021). Understanding how diseases spread globally and locally has become increasingly crucial, especially with recent advancements in information technologies and computing resources which have allowed for more realistic and accurate modeling of disease spreading patterns (Pillai et al., 2024). Recent advances in our understanding of human mobility have significantly shaped the latest generation of epidemiological models. This newfound knowledge has led to more realistic and accurate representations of the global spread of diseases (Fabbri et al., 2024). As a result, researchers can now incorporate the complexities of human mobility to better predict, analyze, and develop strategies for controlling the transmission of infectious agents (Fayad et al., 2023).

Understanding the behavioral dimension in human mobility is crucial for developing realistic models that accurately capture how individuals make decisions related to travel, commuting, and social interactions. It involves investigating the motivations, preferences, and constraints that shape human movement, leading to valuable insights. Various aspects of behavior must be explored, including factors influencing route choices, the frequency and duration of interactions, response to external stimuli, and the overall dynamics of movement patterns. In this context, Marcel Hunecke (2009) delineated two distinct sets of factors influencing individual mobility behavior as personal factors and external factors. The pertinent personal factors influencing individual mobility encompass socio-demographic characteristics and attitudinal factors. Socio-demographic aspects, determining individual options and needs for mobility activities, and attitudinal factors, encompassing values, norms, and attitudes play a pivotal role in shaping preferences and habits regarding specific activities, destinations, routes, and means of transport of individuals (Hunecke, 2009).

Human mobility is manifested at various distances, from short-range (e.g. walking) to long-range (airplane, car, trains, etc.) travelling. In contrast to short-range mobility, which typically spans small distances, long-range transportation covers thousands of kilometers utilizing land, air and sea transportation. In the literature (e.g.., Barbosa et al., 2018), an acceptable grouping consists of intra-urban mobility (covering distances in the range of 1–10 kms), inter-urban mobility (covering a broader range, approximately 100 kms) and lastly, Inter-country and international traveling (extending over distances around 1000 kms).

While the time spent on a given trip is roughly proportional to the distance traveled, the mode of transportation must also be considered, which, in turn, depends on the distance. Short-range travel (like walking, cycling or public transportation) involves slower transportation modes with frequent stops while long-range travel is executed by faster means (like trains or planes) with fewer stops. The relationship between distance, travel times, and speed is described in the work of Varga et al. (2016), which explains the connection between apparent speed (geodesic distance divided by travel time) and travel distance. Additionally, observations indicate that the apparent speed increases with travel distance, following a power-law functional form (Gallotti & Barthelemy, 2014).

Regarding travel time, Marchetti (1994) introduced the concept of a travel time budget in the context of intra-urban mobility. Building on ideas developed by Zehavi (1977), Marchetti suggested a travel time budget of around one hour per day, regardless of the specific location. This suggests that as transportation technology advances, resulting in increased speed, individuals cover longer distance within the allotted time, contributing to urban sprawl. This assumption is captured by the rational locator hypothesis (Levinson & Wu, 2005), suggesting that individuals maintain a roughly constant journey-to-work travel time by adjusting their home and workplace. Additionally, researchers noted that the majority of individuals tend to travel relatively short distances, while a small fraction consistently covers distances exceeding a hundred kilometers. Subsequent investigations (González et al., 2008; Simini et al., 2012) revealed that individual travel patterns converge into a unified spatial probability distribution suggesting that humans exhibit simple and replicable patterns in their movements regardless of the varied nature of their travel experiences.

It is important to note that a trip can involve multiple connections and may be multimodal, incorporating various modes of transportation, each with its associated waiting-time distributions (Gallotti & Barthelemy, 2014). Thus, a deep understanding of mobility necessitates consideration of the multimodal nature of transport and the transitions between different modes. Recent advancements in the analysis of multiplex or multilayer networks have provided a robust framework for conducting such analyses (Boccaletti et al., 2014; Kivela et al., 2014). In these networks, nodes can exist in one or multiple layers, and each layer consists of a set of links or interactions between nodes. When a substantial portion of nodes is present in all discernible layers, the network is termed multiplex.

Traditionally, the development of human mobility models involves extracting information from mobility surveys (Hanson & Huff, 1988; Schlich & Axhausen, 2003). These surveys are designed to collect comprehensive data on travel choices in order to provide detailed travel behaviors of individuals. Nowadays, various methods are employed with Global Positioning System (GPS) traces being the most preferred choice due to their higher spatial and temporal accuracy compared to other techniques. The widespread adoption of mobile phones and use of the GPS marked a turning point, leading to an exponential increase in data generation related to human movement. Combined with continuous advancements in computing power and sophisticated data-mining methods, this transformation enabled the track of movement at finer spatial resolution, for both population and individual level. The increase of mobile phones, particularly the large volume of information gained from call detail records (CDRs) and Online Social Network (OSN) technologies allowed the analysis of human movement at a very fine temporal and spatial resolution. Additionally, the widespread adoption of cell phones globally facilitates multi-scale studies and analyses at various levels, from neighborhoods to entire countries, and even encompassing international travel and movement across borders. However, privacy concerns must be carefully addressed during data collection. While some datasets claim to maintain user anonymity, it is crucial to acknowledge that those collecting the data may still have knowledge of the users. To enhance privacy, data collection should incorporate techniques ensuring user anonymity, like encrypting personal information before database storage or introducing noise to the dataset to prevent the differentiation of individuals' information.

As observed mobility data serve as a vital resource for parameter calibration and model validation, the types of such data found in the literature consist of: records from national censuses, tax revenue, currency transactions, local travel surveys, GPS traces, Wi-Fi access points, online social network, public transport smart cards, bluetooth detection, video tracking, and call detail records. Local surveys, unlike national censuses, offer more detailed information, such as the purpose of travel, frequency and mode of transport. However, the enhanced accuracy, resolution, and variety of meta-data come with a trade-off in spatial extent, as local surveys cover smaller areas (city or neighborhoods) and involve fewer respondents compared to national censuses, which encompass entire countries. Local surveys are often complemented with additional data sources, like GPS tracks. This integration allows for precise records of an individual's position, combined with annotated descriptions of the purposes of each trip (Liang et al., 2013; Schneider et al., 2013). As data from local surveys are constrained by scale and potential self-reporting errors, both local surveys and national censuses lack the capacity to offer a dynamic and comprehensive portrayal of human mobility (Palmer et al., 2013).

Cyprus, like many other countries, experiences diverse mobility patterns among its residents. The choice of transportation modes, such as private vehicles, public transit, walking, or cycling, varies depending on factors like distance, convenience, cost, and infrastructure availability. Urban areas in Cyprus often witness higher levels of congestion during peak commuting hours, leading to increased travel times and environmental impacts. Efforts to promote sustainable transportation alternatives, such as improved public transit systems, cycling infrastructure, and pedestrian-friendly urban designs, aim to mitigate these challenges and promote healthier and more environmentally friendly mobility behaviors.

The motivation behind this research is the considerable lack of mobility data concerning the movement and transportation behaviors of individuals in Cyprus. For this scope, we developed a questionnaire survey which aims to enhance our understanding of the spatiotemporal mobility behaviors of Cyprus residents.

https://doi.org/10.48088/ejg.p.fay.15.4.305.318

2. Methodology

The questionnaire, administered via Google Form, consisted of 23 questions is divided into two main sections (table A1, appendix A). It remained open for a duration of 3 months (from November 20, 2023, to February 20, 2024), during which information was gathered anonymously and voluntarily from residents in Cyprus who were >= 18 years old. In the first part, information regarding demographic (gender, age, district of residence and employment) and key mobility characteristics (frequency, purpose, duration, distance, and means of transportation) is collected. The second section accumulates critical information regarding the mobility timeline of the individuals, indicating location and activity every two hours during a typical day. By analyzing the collected data (responses) from the questionnaire, the mobility profiles of Cypriot residents are created for each age group.

Targeting the adult general population of Cyprus (students, unemployed, employed and retirees), the questionnaire was distributed in various community organizations, patient associations, institutions, universities, educational bodies, and research centers across the areas controlled by the Republic of Cyprus (excluding Turkish-occupied areas). Moreover, to ensure maximum outreach, it was extensively promoted to the general public through digital platforms such as Facebook, X and LinkedIn. To verify the accuracy of the demographic coverage of the participants, a statistical comparison was made with the national census data of the Republic of Cyprus from 2019. Specifically, the latest official census data on the population distribution across five districts of Cyprus were used for comparison (Republic of Cyprus, Statistical Service, 2019). Ethical approval for conducting the questionnaire survey was obtained from the Cyprus National Bioethics Committee [ΕΕΒΚ-ΕΠ2023.01.273]. This ensured that the study is conducted in full compliance with ethical standards and data protection measures.

3. Results

3.1. Demographics

A total of 787 valid and complete responses to the online questionnaire were collected. Across all regions, the majority of participants fall within the age of 25-44, followed by the 45-59 age group (table 1). According to the national census data of the Republic of Cyprus (2019), there is a relatively equal gender split, with women (51%) slightly outnumbering men (49%). In this study, gender distribution is relatively equal across all districts except in Nicosia, which exhibits a slight skew towards males. Consequently, there is a higher proportion of male participants (60%) compared to female participants (40%). The majority of participants (85%) work with physical presence, while a very small percentage (3%) work remotely. Eight percent of the participants are unemployed and 4% are currently retired. Regarding educational status, most participants (77%) are not currently attending an educational institution, while the remaining participants are currently enrolled as students at the bachelor's level (11%), master's level (7%), and doctoral level (5%).

Table 1. Demographics, occupation and education of the participants.

Demographics			**Gender (%)**		**Occupation (%)**				**Currently Student (%)**			
Residency / Age	N	%	Female	Male	On-site	Remote	Retired	Unemployed	Bachelor	Doctoral	Master	Non
Famagusta[1]	**44**	**6**	**2**	**3**	**5**	**0**	**0**	**1**	**1**	**0**	**0**	**4**
< 25	7	1	1	0	0	0	0	1	1	0	0	0
25 – 44	21	3	0	2	3	0	0	0	0	0	0	2
45 – 59	10	1	1	1	1	0	0	0	0	0	0	1
60 +	6	1	0	0	1	0	0	0	0	0	0	1
Larnaca	**91**	**12**	**5**	**6**	**11**	**1**	**0**	**1**	**1**	**1**	**1**	**9**
< 25	5	1	0	0	0	1	0	1	1	0	0	0
25 – 44	63	8	3	5	8	0	0	0	0	1	1	6
45 – 59	16	2	1	1	2	0	0	0	0	0	0	2
60 +	7	1	1	0	1	0	0	0	0	0	0	1
Limassol	**274**	**36**	**16**	**19**	**30**	**0**	**2**	**2**	**3**	**1**	**2**	**27**
< 25	20	3	1	1	1	0	0	1	2	0	0	1
25 – 44	148	19	10	9	18	0	0	1	1	1	2	14
45 – 59	76	10	4	6	9	0	0	0	0	0	0	9
60 +	30	4	1	3	2	0	2	0	0	0	0	3
Nicosia[1]	**334**	**42**	**16**	**26**	**34**	**2**	**2**	**3**	**5**	**3**	**4**	**33**
< 25	26	3	1	2	1	0	0	2	3	0	0	1
25 – 44	177	22	8	14	21	1	0	1	2	2	3	17
45 – 59	92	12	5	7	10	1	0	0	0	1	1	10
60 +	39	5	2	3	2	0	2	0	0	0	0	5
Paphos	**44**	**6**	**1**	**4**	**5**	**0**	**0**	**1**	**1**	**0**	**0**	**4**
< 25	7	1	0	1	1	0	0	1	1	0	0	0
25 – 44	21	3	0	2	2	0	0	0	0	0	0	2
45 – 59	14	2	1	1	2	0	0	0	0	0	0	2
60 +	2	0	0	0	0	0	0	0	0	0	0	0
grand total	**787**	**100**	**40**	**60**	**85**	**3**	**4**	**8**	**11**	**5**	**7**	**77**

[1] Area controlled by the Republic of Cyprus (excluding Turkish-occupied areas).

The highest response rate stands in Nicosia at 42%, closely mirroring its population percentage of 39% based on the national census data of 2019. The region exhibits a dynamic workforce, with a majority engaged in on-site employment (34%) or remote work arrangements (2%). Furthermore, a significant portion of respondents are currently pursuing bachelor-level (5%), master-level (4%), and doctoral-level (3%) studies. Limassol follows with the second-highest response rate of 36%, surpassing its population percentage of 28% as per the national census data of 2019. Larnaca responses contribute to 12% of the total, slightly below its population percentage of 17% according to the national census data of 2019. This suggests a relatively low but still reasonable representation. Similarly, Paphos accounts for 6% of the responses, which is lower but still reasonable representation than its population percentage of 11% (national census data of 2019). Responses from Famagusta represent 6% of the total, which aligns with its population percentage of 5.5% (national census data of 2019). Overall, populations at all districts are well represented in the study (figure 1). Out of the total of 787 individuals who participated in the survey, 217 individuals (27.5%) reported having a chronic health condition for which they receive long-term treatment or are monitored by a specialist. Regarding their physical exercise habits, the majority (44%) reported not exercising at all, while 30% exercise indoors (e.g., gym) and the remaining 26% exercise outdoors.

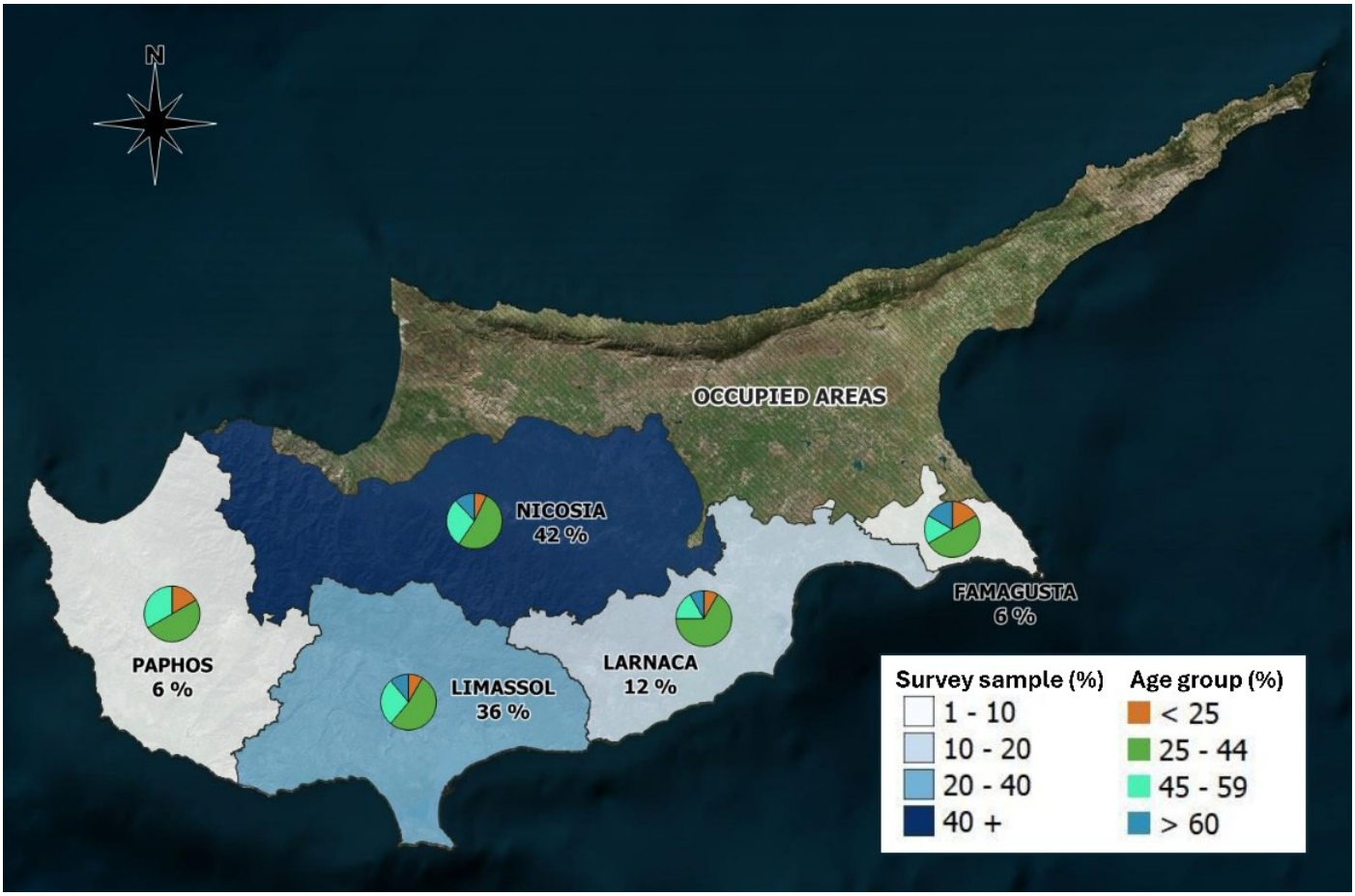

Figure 1. The spatial distribution of the participants closely approximates the population distribution (2019 country census) across the five districts of Cyprus (excluding Turkish-occupied areas). Pie charts illustrate the participation rates by age group.

The survey reveals varying levels of representation across different age groups. While the response rates for age groups between 20 and 64 generally align well with their respective population percentages, there is a substantial underrepresentation of individuals under the age of 20 and those aged 65 and above. Specifically, the response rate of 1% for individuals under 20 contrasts with their population percentage of 22%, indicating a significant disparity. Similarly, the response rate for individuals aged 65 and above falls short, at 5%, compared to their population percentage of 16%, highlighting a notable gap in representation of this age group. Ultimately, the study better captures the behaviors of individuals aged 25-64, who also comprise the most mobile segment of the general population. Further comparison between the survey sample and the latest Cyprus Census data regarding age and gender spatial distribution across the districts (table A2 and A3, appendix B) reveals important insights regarding the representativeness and potential statistical significance of the survey. Starting with Famagusta, the survey captures a balanced gender distribution, with 3.68% males and 1.91% females, closely matching the census figures of 2.76% and 2.79%, respectively. Age-wise, most groups are well represented, with only minor differences and minimal variations. In Larnaca, males are somewhat under-represented (6.99% vs. 8.34% in the census), and females more notably so (4.57% vs. 8.70%). Younger age groups, such as 20-24 (0.66% vs. 2.17%) and 25-29 (1.33% vs. 2.35%), are slightly under-represented, while middle-aged groups like 30-34 (2.65% vs. 2.15%) and 35-39 (2.26% vs. 1.93%) align more closely with the census data. In Limassol, both males (19.06% in the survey vs. 13.52% in the census) and females (15.76% in the survey vs. 14.48% in the census) are well represented, with a particularly strong showing among males. In terms of age, middle-aged groups (30-44) are strongly represented, particularly the 35-39 group (5.87% vs. 3.19%). For Nicosia, the gender distribution is slightly skewed, with males comprising 26.43% of the survey compared to 18.83% in the census, while females are slightly under-represented (16.01% vs. 20.08%). Age-wise, there is a balanced

https://doi.org/10.48088/ejg.p.fay.15.4.305.318

age representation, with slight under-representation in younger groups like 20-24 (3.36% in the survey vs. 4.81% in the census) and 25-29 (4.16% vs. 5.56%) and slight over-representation in middle-aged groups, such as 35-39 (7.66% vs. 4.57%) and 40-44 (6.58% vs. 4.27%). Finally, in Paphos, although both males (4.19% in the survey vs. 5.19% in the census) and females (1.40% vs. 5.32%) are under-represented, the survey still offers valuable insights into gender distribution in the region, with females being more notably under-represented. Age-wise, most groups are well represented, with only minor differences and minimal variations.

In evaluating the representativeness of the survey sample in comparison to census data, t-tests were conducted on the gender and age distributions across all districts (table A4 and A5, appendix B). The t-test results for gender in each district indicated no statistically significant differences, with p-values comfortably above the 0.05 threshold. The lowest values of Larnaca ($p = 0.155$) and Limassol ($p = 0.186$), still approach acceptability. This suggests that the gender composition within each district's survey sample closely aligns with the actual population proportions, supporting the sample's representativeness in terms of gender. The analysis of age group representativeness yielded mostly positive results. Famagusta ($p = 0.967$), Larnaca ($p = 0.068$), Limassol ($p = 0.137$) and Nicosia ($p = 0.551$) show no statistically significant differences, indicating that the age distributions in these survey samples reliably reflect their respective populations. Paphos ($p = 0.001$) show some statistical difference, though still close to conventional thresholds in representativeness, particularly given the broad age range included. Island-wide, gender and age distribution of the survey sample closely aligns with Cyprus census data, as indicated by high p-values for both genders (male: $p = 0.675$; female: $p = 0.620$) and across all age groups (p-values ranging from 0.293 to 0.935). These results confirm the sample's representativeness for gender and most age groups, supporting the reliability of generalizing demographic-related findings from the survey to the broader population in Cyprus, with some caution advised for certain districts and age group inferences.

3.2. Travel Distance

Table 2 illustrates data on traveling distances for various activities. According to survey findings, the majority (60%) of respondents prefer engaging in entertainment and dining activities within a short 10 km distance, with an additional 23% willing to travel between 10 and 20 km for this purpose. For grocery shopping, most participants (64%) opt for locations within a 5 km range, while 26% are comfortable traveling between 5 and 10 km. The remaining distances for grocery shopping show a relatively even distribution. Similarly, general shopping activities exhibit a preference for shorter distances, with 76% of participants traveling within a 10 km radius and an additional 14% within a 10 – 20 km range. Overall, the data indicates a tendency for people to remain at relatively short distances for everyday activities like grocery shopping, while being more open to traveling longer distances for entertainment, dining, and general shopping purposes.

Table 2. Participants' responses regarding traveling distances for various activities.

Traveling Distance	Entertainment & Dining (N)	Entertainment & Dining (%)	Grocery Shopping (N)	Grocery Shopping (%)	Shopping (N)	Shopping (%)
< 5 km	160	20	501	64	301	38
5 - 10 km	312	40	201	26	299	38
10 - 20 km	184	23	58	7	110	14
20 - 30 km	69	9	14	2	36	5
> 30 km	62	8	13	2	41	5
grand total	**787**	**100%**	**787**	**100%**	**787**	**100%**

The overall trend of higher engagement within shorter traveling distances (< 10 km) is consistent across all age groups (Table 3). Despite some fluctuations, the pattern of preferring nearby locations for daily activities like grocery shopping and entertainment remains prevalent across all age groups. Additionally, the majority of participants across all age groups show reluctance to travel distances exceeding 20 km for any activity, particularly for grocery shopping. Participants under the age of 25 (constituting 8% of the sample) predominantly travel distances below 5 km, mainly for grocery shopping (55%), while opting for longer distances primarily for entertainment and dining purposes. The remaining age groups follow a similar pattern with participants aged 25 to 44 (comprising 55% of the sample), 45 to 59 (26% of the sample) and over 60 years old (11% of the sample) predominantly travel distances below 5 km mainly for grocery shopping (63%, 68% and 64% respectively). In general, longer distances are primarily traveled for entertainment and dining purposes. It is noteworthy that movements within distances less than 5 km are mostly carried out by individuals in older age groups (45-59 and 60+ years), accounting for the majority within their respective age group (46%). Additionally, travels exceeding 20 km are primarily undertaken by individuals under the age of 25, for the purposes of entertainment, dining and general shopping, constituting the majority (18%) within the age group.

Table 3. Participants' responses regarding traveling distances for various activities, by age group.

traveling distance	entertainment and dining	grocery shopping	shopping	total	% of all participants
Age < 25					**8%**
< 5 km	17%	55%	37%	36%	3%
5 - 10 km	31%	23%	25%	26%	2%
10 - 20 km	29%	12%	18%	20%	2%
20 - 30 km	12%	5%	12%	10%	0.5%
> 30 km	11%	5%	8%	8%	0.5%
Age 25 - 44					**55%**
< 5 km	18%	63%	34%	38%	21%

https://doi.org/10.48088/ejg.p.fay.15.4.305.318

5 - 10 km	42%	27%	43%	37%	20%
10 - 20 km	24%	8%	15%	16%	9%
20 - 30 km	9%	1%	5%	5%	3%
> 30 km	8%	1%	3%	4%	2%
Age 45 - 59					**26%**
< 5 km	24%	68%	46%	46%	12%
5 - 10 km	38%	22%	33%	31%	8%
10 - 20 km	24%	6%	12%	14%	4%
20 - 30 km	8%	2%	2%	4%	1%
> 30 km	6%	2%	7%	5%	1%
Age 60 +					**11%**
< 5 km	29%	64%	44%	46%	5%
5 - 10 km	39%	27%	36%	34%	4%
10 - 20 km	15%	6%	10%	10%	1%
20 - 30 km	5%	1%	4%	3%	0.5%
> 30 km	12%	1%	7%	7%	0.5%

3.3. Mobility Frequency

Tables 4 and 5 record the frequency of participants' movements (per week) for various activities and purposes. In this study 'Entertainment' refers to leisure venues (such as theaters, cinemas, events, festivals, etc.), 'Dining' refers to food establishments (such as restaurants, taverns, cafes, pizzerias, breweries, bars, etc.), 'Physical exercise and sports' refers to exercise venues (such as gyms and outdoor spaces), 'Grocery shopping' refers to food retail locations (such as supermarkets, grocery stores, mini markets, kiosks, etc.) and 'General shopping' refers to retail spaces for goods and services other than food.

Regarding the purpose for which they do not travel at all, a high number of participants do not include visits to sports facilities (51%) and general shopping (24%) in their weekly schedule. Additionally, many individuals do not visit dining (16%) and entertainment venues (14%) and others rarely visit other households on a weekly basis (8%). Eleven percent of the participants do not need to commute to their workplace.

Table 4. Participants' responses regarding weekly travelling frequencies for various activities.

Mobility Freq. (times/week)	Workplace	Visiting Other Houses	Entertainment	Dining	Physical Exercise & Sports	Grocery Shopping	Shopping
0	11%	8%	14%	16%	51%	6%	24%
1	3%	32%	36%	42%	15%	30%	49%
2	11%	24%	25%	23%	12%	32%	14%
3	7%	17%	14%	11%	10%	15%	6%
4	3%	5%	4%	3%	5%	7%	2%
5 +	65%	14%	7%	5%	7%	10%	5%

By category and in descending order, most people commute more than 5 times per week for workplace (65%), once for shopping (49%), once for dining (42%), once for entertainment (36%), once for visiting other houses (32%), twice for grocery shopping (32%), and once for physical exercise and sports (15%). Lastly, at least three times per week, participants commute for workplace (75%), visiting other houses (36%), grocery shopping (32%), entertainment (25%), physical exercise and sports (22%), dining (19%), and shopping (13%).

Table 5 displays the frequency and the preferred mode of transportation of the participants for five primary purposes of travel (to/from university, to/from workplace, to/from children's school, within district of residence and outside district of residence). Across all modes of transportation (car, motorbike, bus, taxi, bicycle, walk) the two most popular are presented for each category.

Table 5. Participants' responses regarding weekly travel frequencies and preferable mode for various purposes.

Mobility Freq. (times/week)	To/From University		To/From Workplace		To/From School (children)		Within District of Residence		Outside District of Residence	
	Car	Walk	Car	Walk	Car	Bus	Car	Walk	Car	Bus
1-2	4%	4%	7%	5%	4%	2%	6%	35%	52%	4%
3-5	12%	3%	28%	4%	16%	4%	19%	14%	13%	1%
5-10	6%	2%	34%	1%	16%	2%	28%	4%	8%	1%
10+	9%	2%	20%	1%	7%	1%	45%	3%	10%	1%
grand total	**31%**	**11%**	**88%**	**11%**	**43%**	**9%**	**98%**	**56%**	**83%**	**7%**

According to the participants, commuting to/from the university is predominantly done by car (31%) and by foot (11%), mostly 3-5 times per week. Similarly, commuting to/from the workplace is principally done by car (89%) over walking (11%), between 5-10 times per week for most people. For participants' children commuting to/from school, most do so 3-5 times weekly, with a notable preference for cars (43%) and buses as

the immediate alternative (9%). Regarding movements within the district of residence, these are mostly done by car (98%) and walking (56%), more than 10 times per week by most people. Significant car usage is also observed for commuting outside the district of residence, at 83%, followed by buses at only 7%. Notably, these commutes occur at most 1-2 times per week. Compared to other modes of transportation, car usage appears to dominate across all categories. Walking takes second place in preference for travelling to/from university, to/from workplace and within district of residence, followed by buses in third place for travelling to/from children's school and outside district of residence.

3.4 Spatial variability of mobility behaviors

In Famagusta, a significant portion of participants (50–56.8%) reported traveling less than 5 km for grocery shopping and general shopping, while entertainment and dining trips were somewhat more distributed, with 38.6% traveling 5–10 km. Travel beyond 20 km is rare, indicating localized mobility in this region. Workplace mobility is notably high, with 63.6% of participants traveling to work five or more times a week, indicating regular commuting patterns. However, for social visits, entertainment, and dining, mobility is generally lower, with most participants engaging in these activities only one or two times per week. Physical exercise is infrequent in the district, as 59.1% report no participation in sports or exercise. Grocery shopping is primarily done twice a week (34.1%), while non-essential shopping occurs less often, with 38.6% of participants shopping only once per week.

In Larnaca, participants also tend to travel shorter distances for groceries, with 50.5% staying within 5 km. However, entertainment and dining activities are spread out more evenly between different distances, with 31.9% traveling 5-10 km and another 31.9% traveling 10-20 km. Shopping behavior is more evenly distributed, with a notable portion of 33% traveling less than 5 km, 28.6% traveling 5-10 km and 25.3% traveling 10-20 km. Workplace mobility is significant, with 61.5% of participants commuting five or more times weekly. Social visits and entertainment are more frequent compared to Famagusta, with 35.2% and 39.6% of participants, respectively, visiting other houses and engaging in entertainment activities once per week. Dining out is also common, with 45.1% reporting they dine once per week. Physical exercise in Larnaca is also low, with 59.3% of participants not engaging in any form of exercise. Grocery shopping habits are similar to Famagusta, with most people shopping two times a week (35.2%).

Limassol shows a strong tendency for short-distance grocery shopping, with 62% of participants traveling less than 5 km. Shopping patterns are slightly more distributed, with 39.4% traveling 5-10 km and 36.1% traveling less than 5 km. For entertainment, there is significant movement within 5-10 km (40.1%). Workplace mobility is also high, with 64.6% of participants commuting five or more times per week. Social visits (30.7%) and entertainment (39.1%) occur mostly once a week, and dining is frequent, with 44.2% dining out weekly. Physical exercise follows the same trend as other districts, with 51.1% reporting no regular activity. Grocery shopping is frequent, with 30.3% shopping once per week and 34.3% shopping twice weekly, while shopping for non-essentials is less common, with 50.4% of participants engaging in it just once a week.

In Nicosia, short-distance grocery shopping is dominant, with 71.9% of participants traveling less than 5 km. However, for entertainment and dining, there is a larger spread across distances, with 41.9% traveling 5-10 km. Shopping behaviors mirror entertainment, with 41% of participants traveling similar distances. Notably, in this district workplace mobility reaches its peak, with 67.1% commuting five or more times per week, the highest rate among all districts. Social visits (31.7%) and dining (41.6%) are most commonly done once a week. Physical exercise shows slightly lower inactivity (47%) compared to other districts, though still a large proportion of people remain inactive. Grocery shopping in Nicosia is frequent, with 34.1% shopping once a week, and similarly, non-essential shopping follows a similar pattern, with 48.2% shopping once weekly.

Paphos shows a more distributed travel pattern. For grocery shopping, 45.5% travel less than 5 km, but 36.4% travel between 5-10 km. Shopping and entertainment follow similar patterns, with a large proportion traveling within 5-10 km (38.6% for both activities). Workplace mobility remains high, with 65.9% of participants commuting five or more times per week. Social visits (27.3%) and dining (27.3%) occur mostly once per week. Entertainment activities are more frequent in Paphos compared to other districts, with 40.9% of participants engaging in entertainment once a week. Physical exercise remains low, with 52.3% reporting no activity. Grocery shopping is slightly less frequent compared to other districts, with a notable proportion (27.3%) shopping twice a week.

3.5. Mobility timeline

In their typical working day, most participants respect the following mobility schedule (figure 2). The majority of people (> 84%) are at home from the beginning of the day until 6 am. Then, a gradual transition to other locations and activities begins, such as commuting for work purposes (11%) and physical exercise (3%). From 8 am until 4 pm, most of the people are at their workplace (> 54%), at home (> 23%), and at their academic institution (> 6%). At 6 pm, participants are mostly at home (30%), workplace (25%), grocery shopping locations (13%) and engaging in physical exercise (12%). From 8 pm until the end of the day, there is a rising trend for returning home by most (> 57%), while the number of people engaged in sports (8%), workplace (7%) and entertainment (7%) and dining venues (6%) is gradually decreasing.

On a typical Saturday (figure 3), the majority of people (from 36% to 94%) are at home throughout the day. Meanwhile, the following activities are also depicted. From the beginning of the day until 6 am, a small number of individuals are at their workplace (2%) and at entertainment (2%) and dining venues (1%). From 8 am until 6 pm, there is an increase in the number of people at their workplace (up to 12%) and at sports facilities (up to 7%). Most visits (up to 12%) to other houses are recorded between 2 pm and 10 pm. Transitions for grocery shopping (up to 14%) and shopping (up to 6%) occur between 10 am and 4 pm. Meanwhile, from 10 am until midnight, there is a high interest in transitioning to entertainment (up to 21%) and dining (up to 17%) venues.

On a typical Sunday (figure 4), there is a fairly similar profile to that of a typical Saturday. Once again, the majority (39% to 94%) of people are at home throughout the day. However, there is increased interest in other activities. Transition for physical exercise is done by most individuals (up to 5%) between 8 am and 12 noon. A high number of people (10% to 15%) visit other houses from noon until 6 pm while from 8 am until 10 pm, there is a steady percentage of people at their workplace (6%) and a rapid increase in activities related to entertainment (up to 16%) and dining (up to 19%). From 8 pm until the end of the day, the majority of participants (> 64%) are back at their homes.

4. Discussion

This study focused on the mobility behaviors of individuals aged 20-64, the most active demographic segment in Cyprus, offering key insights into their travel patterns, commuting habits and preferences regarding transportation modes and destinations. The dataset analyzed offers several

unique advantages and added value, particularly when compared to the larger-scale reports typically produced by the European Commission. While European Commission data provides a broad overview and macro-level trends, the localized, district-specific insights offered by this study make this survey data set particularly valuable for more targeted, regional-level analysis and decision-making. Furthermore, survey dataset differs from other datasets like MapBox Movement, Strava, social media data, and Google's Community Mobility Report in several key ways. While these alternative datasets are often based on passive data collection from mobile devices, apps, or social media activity, the current survey dataset is based on direct responses from participants, offering qualitative insights alongside quantitative data. This means that it captures not only mobility patterns but also the underlying motivations, perceptions, and opinions of individuals regarding their behavior. In contrast, datasets like Google's Community Mobility Reports or MapBox provide high-frequency, real-time movement data, but lack the context of why people are moving or adhering to certain behaviors. Strava and similar platforms are also more focused on specific activities like exercise, and their user bases are typically self-selected and not always representative of the general population. The survey dataset presented in this paper, with its demographic matching to the census, provides a more representative and comprehensive view of mobility and behavior making it a valuable complement to more granular, real-time movement data from other sources.

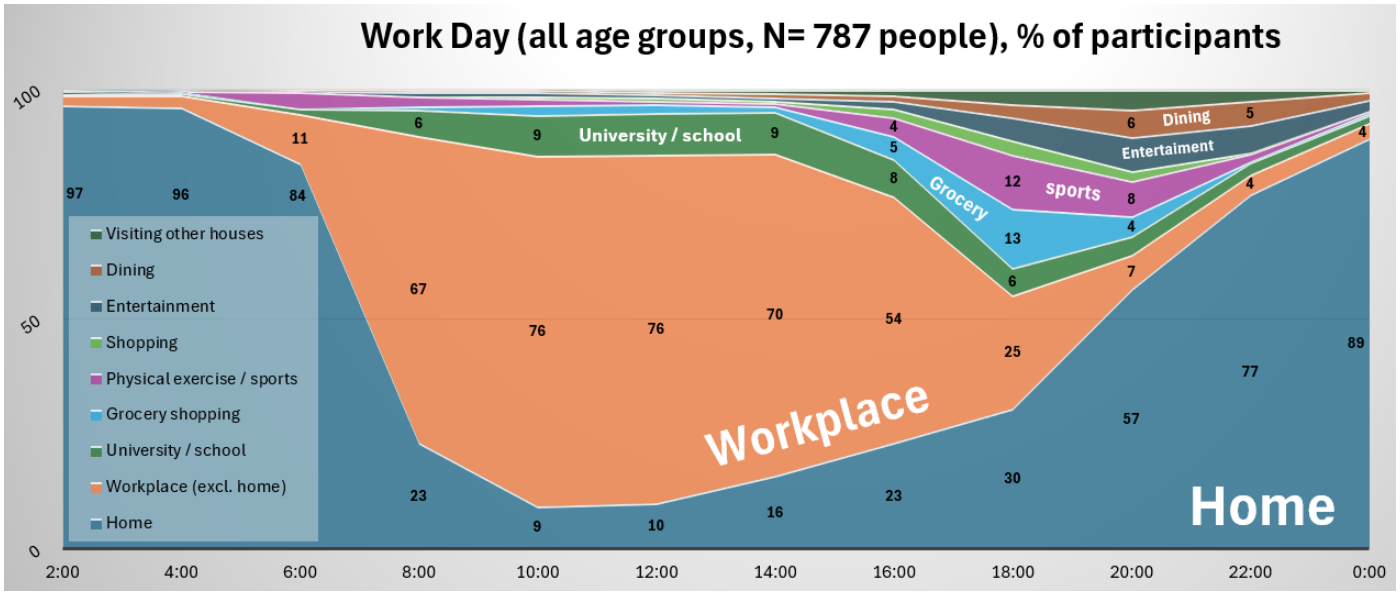

Figure 2. Participants' responses regarding their mobility timeline, portraying location and activity every two hours, during a typical workday.

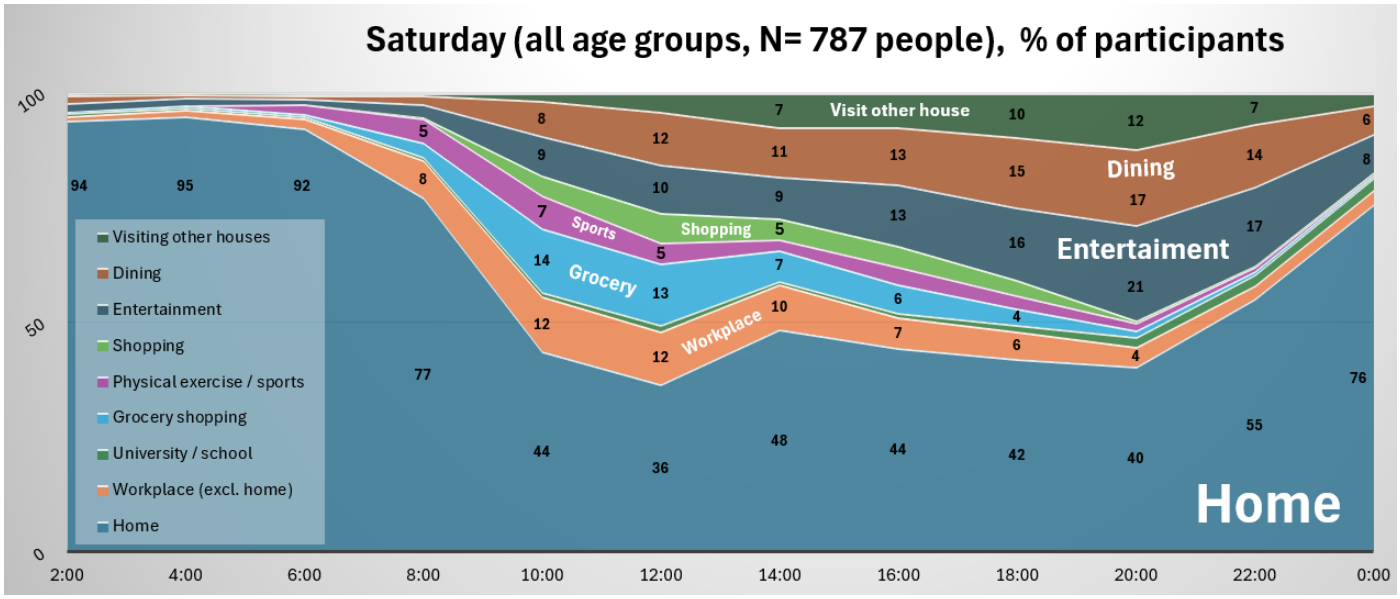

Figure 3. Participants' responses regarding their mobility timeline, portraying location and activity every two hours, during a typical Saturday.

https://doi.org/10.48088/ejg.p.fay.15.4.305.318

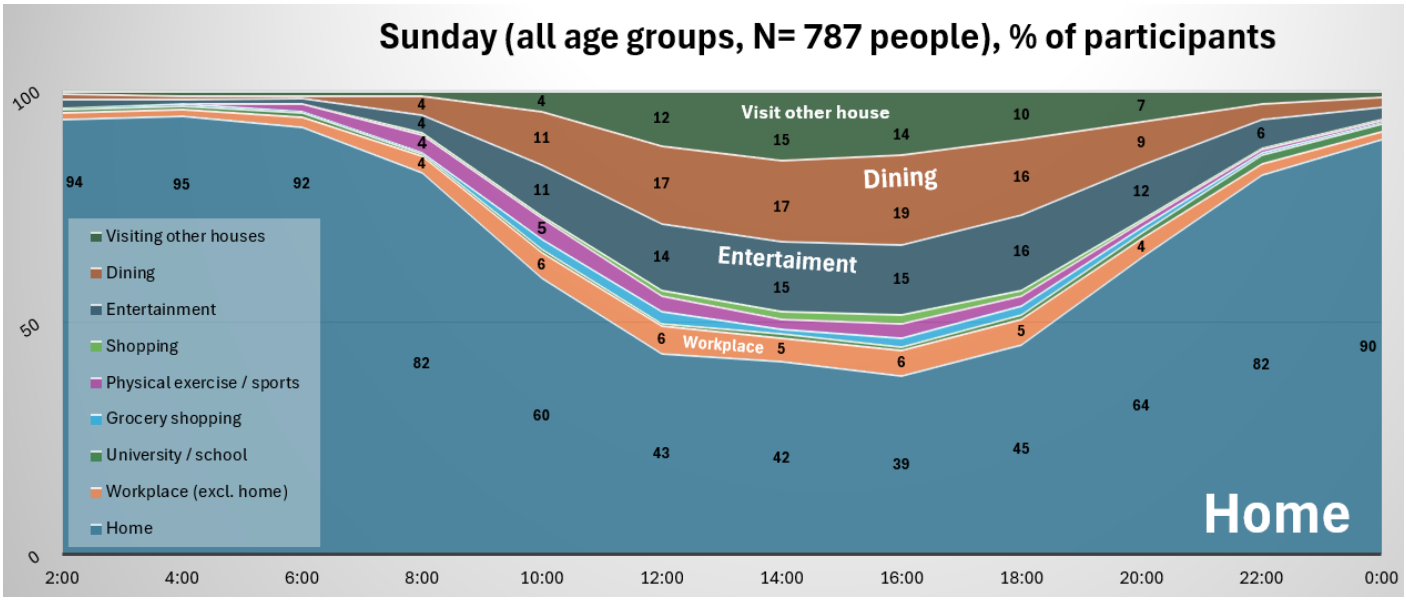

Figure 4. Participants' responses regarding their mobility timeline, portraying location and activity every two hours, during a typical Sunday.

Populations from all districts of Cyprus are well represented, capturing regional variations in mobility behaviors. A clear timeline of daily mobility was established, highlighting activity and location changes at two-hour intervals during typical workdays, Saturdays, and Sundays.The survey sample demonstrates a generally good alignment with the census data, with minor variations in gender and age group representation across districts. In Famagusta, gender distribution is well-balanced, closely matching census data. Larnaca shows a reasonable match for males but a more noticeable under-representation of females. Limassol demonstrates strong representation for both genders, with a noticeable over-representation of males, while Nicosia exhibits robust male representation and a slight under-representation of females. Age-wise, the survey shows strong representation among middle-aged cohorts (30-44) in most districts, with under-representation among younger age groups (particularly 20-29) in districts like Larnaca and Paphos. While Paphos shows some under-representation for both genders and younger age groups, the district still contributes valuable demographic insights. Overall, the survey sample provides a reliable demographic overview and reflects the general population trends across Cyprus. Island-wide results suggest that the sample is statistically representative of the population in terms of both gender and age distributions, enabling credible generalizations of age- and gender-related insights to the broader population in Cyprus.

The findings reveal that residents generally tend to travel shorter distances, particularly for routine activities like grocery shopping, while they are more inclined to venture further for entertainment, dining, and general shopping. This pattern of shorter travel distances, particularly within 10 kilometers, holds true across all age groups. The latest National Travel Survey (Statistical service of the Republic of Cyprus, 2010) supports this, showing a high car usage rate (84% of participants) with an average trip duration of 15 minutes and an average trip distance of 10 kilometers per person. Additionally, our study finds that longer distances are predominantly traveled for entertainment and dining purposes. Interestingly, individuals aged 45 and above are more likely to make movements within distances less than 5 kilometers, while those under 25 are more prone to travel distances exceeding 20 kilometers, mainly for entertainment, dining, and general shopping purposes. Shorter travel distances (<5 km) are more common for grocery shopping across all districts, especially in Nicosia and Limassol, likely due to urban density and proximity to services. In contrast, entertainment and dining often involve slightly longer trips, particularly in districts like Larnaca and Paphos.

Regarding mobility frequency and transportation preferences, on a weekly basis most individuals commute more than five times per week for work, once for shopping, once for dining, once for entertainment, once for visiting other houses, twice for grocery shopping and once for physical exercise and sports. Workplace mobility is consistently high across all districts, particularly in Nicosia and Paphos. Entertainment and dining tend to be more frequent in Limassol and Nicosia, where participants engage in these activities more often. Physical exercise shows a general trend of inactivity across all districts, while grocery shopping is commonly done once or twice per week, with higher frequencies in urban districts like Limassol and Nicosia. These patterns reflect how urban planning, population density, and available services shape mobility behavior.

Car usage is the predominant mode of transportation across all categories. Walking emerges as the second most preferred mode for commuting to and from university, work, and within the district of residence. Buses rank third for traveling to and from children's school and outside the district of residence. Most of the above findings align with the recent European Commission report on mobility patterns (CEU. MOVE. et al., 2022). According to that study, Cyprus stands out with the highest percentage (26%) of car trips for distances under 3 km, yet it has the lowest percentage (29%) for trips over 10 km among the 27 EU countries. Driving is particularly dominant, accounting for about 70% of travel time on working days (the highest proportion in the EU) with an average car trip of 23 minutes at an average speed of 33 km/h. Regarding short distance travelling (trips under 300 km) per person, Cyprus reports a daily average of 38 km (40% higher than the EU average) and daily average duration of 70 minutes (slightly below the EU average). Urban mobility (trips under 100 km within the same Functional Urban Area) sees an average travel distance of 10 km per person per day and an average duration of 21 minutes. The study also indicate that Cyprus also leads in car ownership, with 32% of individuals living in households with three or more cars, vastly exceeding the EU average of 6%. Two Eurobarometer reports find similar results. The reports from the European Commission (2014, 2015) highlight a high dependence on cars, with over 80% of respondents using a car daily, and note that Cyprus has the lowest usage of public transport services in the EU.

The mobility timeline of Cyprus residents on a typical workday exhibit distinct patterns throughout the day. In the early morning hours, the majority of individuals (> 84%) remain at home, with a gradual transition to other activities such as commuting for work and physical exercise

starting at 6 am. During typical working hours (8 am to 4 pm), most people are at their workplace, while others are at home or academic institutions. By 6 pm, there is a notable shift, with a significant portion of individuals returning home, while others are still engaged in activities like grocery shopping, physical exercise, or remaining at work. Towards the end of the day, the trend leans heavily towards returning home (> 57%), with fewer individuals engaged in sports, work, entertainment, or dining out. On a typical Saturday, the mobility timeline of Cyprus residents reflects a pattern where the majority of individuals (ranging from 36% to 94%) remain at home throughout the day. Early in the morning until 6 am, a small percentage are already at their workplace or entertainment and dining venues. From 8 am to 6 pm, there is a notable increase in individuals at their workplace and sports facilities. Visits to other houses peak between 2 pm and 10 pm, while transitions for grocery shopping and general shopping occur between 10 am and 4 pm. Moreover, from 10 am until midnight, there is a significant interest in transitioning to entertainment and dining venues, suggesting a preference for leisure activities and dining out during weekends. On a typical Sunday, the mobility timeline of Cyprus residents closely mirrors that of a typical Saturday, with the majority (ranging from 39% to 94%) remaining at home throughout the day. Notable patterns include a transition for physical exercise by most individuals in the morning hours, followed by a significant number visiting other houses during the afternoon. From morning until early evening, there is a consistent percentage of individuals at their workplace, while activities related to entertainment and dining see a rapid increase, peaking in the late afternoon and evening hours. By the end of the day, the majority of participants have returned to their homes, indicating a trend towards winding down and relaxation as the weekend draws to a close. Despite the recent COVID-19 pandemic, the vast majority of participants are currently working with physical presence, suggesting minimal impact on employment statuses or remote work adoption. Exercise habits vary, with a significant portion not exercising at all, while others prefer indoor or outdoor activities. The high percentage of 44% reporting no exercise at all, indicates an increased tendency towards sedentary lifestyles in the population. The lack of physical activity may be associated with various factors such as professional obligations to work in physical presence and preference for other activities besides exercise. As sedentary lifestyles can have negative impacts on health, it is important for people to incorporate physical activity into their daily routines for their overall well-being.

In the context of this study, several limitations are acknowledged. Firstly, the lack of detailed information on the exact locations of transitions limits the ability to analyze mobility patterns in higher spatial resolution. Secondly, the survey records human movement with a two-hour interval. This temporal resolution may overlook short-term mobility events, potentially leading to an incomplete understanding of short-duration trips and rapid movement changes. Lastly, the use of an electronic questionnaire presents a barrier for individuals not well-versed in technology, particularly older adults, resulting in potential underrepresentation of certain demographic groups and a bias towards more tech-savvy participants.

5. Conclusion

This study provides valuable insights into the mobility behavior of Cyprus residents, particularly those aged 20-64, across various districts and activities. It highlights a strong dependence on cars, short-distance travel for routine activities, and variability based on regional and activity-specific factors. Daily mobility patterns and behavior have been recorded.

The added value of this study lies in its detailed, district-specific insights that possibly allow for localized policy and decision-making, thus providing additional information beyond national-level data. Additionally, we believe that the findings of this work contribute significantly to the broader mobility literature and research, because such findings pertain to inhabitants of a small, island, country. The geographical constraints and compactness of Cyprus lead to distinctive mobility dynamics compared to larger countries. Cyprus exhibits a unique set of mobility patterns characterized by high frequencies of short travel distances, integrated urban-rural travel dynamics due to the close proximity of rural areas to urban centers and high infrastructure density. These lead to increased connectivity, making transportation options more readily available and efficient. Additionally, the centralization of services plays a crucial role. Major services such as healthcare, education, and government services are primarily located in a few urban centers. This centralization necessitates travel from surrounding areas to these hubs, influencing mobility patterns significantly. The study's findings have important implications for urban planning and transportation policies in Cyprus. Planners and policymakers should focus on reducing car dependence, improving alternative transportation options, and promoting active lifestyles to address the public's low engagement in physical exercise.

Future research can build on the current dataset by conducting longitudinal surveys to track changes in mobility patterns and attitudes over time. Integrating the data with real-time mobility sources like Google's Community Mobility Reports or MapBox could provide a more comprehensive view of both quantitative movement trends and the qualitative reasons behind them. Additionally, expanding the research to more granular, city-specific levels or comparing with other regions or countries could offer deeper insights into urban-rural or cultural differences. Modeling how demographic factors influence mobility behavior would help refine policy interventions, while a closer look at demographic subgroups would aid in targeting specific population segments more effectively.

Funding: The PhD research titled "Agent-based modelling and simulation of human mobility in the context of infectious disease spread" (epimogeo-covid.cut.ac.cy) is conducted at the Department of Civil Engineering and Geomatics of the Cyprus University of Technology. The research has received scholarship grants from the State Scholarships Institution of Cyprus (cyscholarships.gov.cy) and the Sylvia Ioannou charitable foundation (sylviaioannoufoundation.org).

Data Availability Statement: Data is available on request. Please contact the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

Appendix A

Table A1. Survey structure.

SURVEY TITLE: "Capturing the spatio-temporal mobility behaviors of the residents in the Republic of Cyprus"

PART 1 out of 3: Consent form to data confidentiality and data processing

1. **I confirm that I am 18 years old and above**
   (answers: AGREE, DO NOT AGREE)
2. **I agree to the processing of personal data and to take part in the survey**
   (answers: AGREE, DO NOT AGREE)

PART 2 out of 3: Demographics and key mobility characteristics

1. **Gender**
   (answers: Male, Female)
2. **Age Group**
   (answers: <20, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, 65+)
3. **Chronic Disease**
   (answers: Yes, No)
4. **District of residence**
   (answers: Limassol, Nicosia, Larnaka, Paphos, Famagusta)
5. **Region of residence**
   (answers: choose one of 442 Communities and Municipalities)
6. **Occupation**
   (answers: Unemployed, On-site presence, Remote, Retired)
7. **District of employment**
   (answers: Unemployed / Retired / Remote work, Limassol, Nicosia, Larnaka, Paphos, Famagusta)
8. **Region of employment**
   (answers: Unemployed / Retired / Remote work, I do not know, choose one of 442 the Communities and Municipalities)
9. **Currently attending an academic institution?**
   (answers: Not a student, BSc student, MSc student, PhD student)
10. **District of studies**
    (answers: Not a student, Remote studies, Limassol, Nicosia, Larnaka, Paphos, Famagusta)
11. **How often (times per week) do you use the following means of transport for your transition <u>to/from your school</u>?**
    (answers: 0, 1-2, 3-5, 5-10, 10+)
    - Car
    - Motorbike
    - Bus
    - Taxi
    - Bicycle
    - Walk
12. **How often (times per week) do you commute for the following purposes, on average?**
    (answers: 0, 1, 2, 3, 4, 5, 5+)
    - Workplace
    - Visiting another home (family and friends)
    - Entertainment (e.g. theatre, Cinema, Events, Festivals, etc)
    - Dining (e.g. Restaurants, Taverns, Cafes, Pizzerias, Bars, etc.)
    - Physical exercise and sports (training areas, gym, indoor and outdoor)
    - Grocery shopping (Supermarket, Mini Market, Kiosk, etc)
    - Shopping (Retail stores, Services and Goods other than food)
13. **How often (times per week) do you use the following means of transport for your transition <u>within</u> your district of residence?**
    (answers: 0, 1-2, 3-5, 5-10, 10+)
    - Car
    - Motorbike
    - Bus
    - Taxi
    - Bicycle
    - Walk
14. **How often (times per week) do you use the following means of transport for your transition <u>outside</u> your district of residence?**
    (answers: 0, 1-2, 3-5, 5-10, 10+)
    - Car
    - Motorbike

https://doi.org/10.48088/ejg.p.fay.15.4.305.318

- Bus
- Taxi

15. **How often (times per week) do you use the following means of transport for your transition to/from your workplace?**
(answers: 0, 1-2, 3-5, 5-10, 10+)
    - Car
    - Motorbike
    - Bus
    - Taxi
    - Bicycle
    - Walk
16. **How often (times per week) the following means of transport are being mostly used for the transition of your children to/from school?**
(answers: 0, 1-2, 3-5, 5-10, 10+)
    - Car
    - Motorbike
    - Bus
    - Taxi
    - Bicycle
    - Walk
17. **Starting from your location of residence, how far do you usually travel for your shopping (retail stores - Services and Goods other than food)?**
(answers: <5 km, 5-10 km, 10-20 km, 20-30 km, >30 km)
18. **Starting from your location of residence, how far do you usually travel for your entertainment (e.g. theatre, Cinema, Events, Festivals, etc) and dining (e.g. Restaurants, Taverns, Cafes, Pizzerias, Bars, etc.)**
(answers: <5 km, 5-10 km, 10-20 km, 20-30 km, >30 km)
19. **Starting from your location of residence, how far do you usually travel for your grocery shopping (Supermarket, Mini Market, Kiosk, etc)?**
(answers: <5 km, 5-10 km, 10-20 km, 20-30 km, >30 km)
20. **State the type of venue you use mostly, for your physical exercise and sports**
(answers: Indoor space (e.g. gym), Outdoor space (e.g. park), I don't exercise)

PART 3 out of 3: Human Mobility Schedule

In this section, for each question the participant must choose one option from the following location/activity list for each timeslot.

Timeslots: 2 am, 4 am, 6 am, 8 am, 10 am, 12 am, 2 pm, 4 pm, 6 pm, 8 pm, 10 pm, 12 pm

Location/activity list:

- Home
- Workplace (not home)
- University / School
- Entertainment (e.g. theatre, Cinema, Events, Festivals, etc)
- Dining (e.g. Restaurants, Taverns, Cafes, Pizzerias, Bars, etc.)
- Physical exercise and sports (training areas, gym, indoor and outdoor)
- Grocery shopping (Supermarket, Mini Market, Kiosk, etc)
- Shopping (Retail stores, Services and Goods other than food)
- Visiting other houses (family and friends)

1. **Determine your indicative location every two hours, for a typical workday**
(answers: choose one option from the location/activity list for each timeslot)
2. **Determine your indicative location every two hours, for a typical Saturday**
(answers: choose one option from the location/activity list for each timeslot)
3. **Determine your indicative location every two hours, for a typical Sunday**
(answers: choose one option from the location/activity list for each timeslot)

END OF SURVEY

https://doi.org/10.48088/ejg.p.fay.15.4.305.318

Appendix B

Table A2. Percentage of participants by age group. Survey sample vs Cyprus census 2019 (in parenthesis).

	20 - 24	25 - 29	30 - 34	35 - 39	40 - 44	45 - 49	50 - 54	55 - 59	60 - 64	total
Famagusta	0.70 (0.67)	0.14 (0.71)	0.70 (0.70)	0.97 (0.65)	1.12 (0.64)	0.56 (0.62)	0.70 (0.59)	0.14 (0.52)	0.56 (0.45)	5.59 (5.55)
Larnaca	0.66 (2.17)	1.33 (2.35)	2.65 (2.15)	2.26 (1.93)	2.13 (1.90)	1.06 (1.88)	0.8 (1.78)	0.27 (1.48)	0.40 (1.37)	11.56 (17.01)
Limassol	2.67 (3.45)	3.60 (3.80)	4.67 (3.58)	5.87 (3.19)	5.60 (3.13)	4.27 (3.06)	3.74 (3.01)	2.13 (2.47)	2.27 (2.31)	34.82 (28.00)
Nicosia	3.36 (4.81)	4.16 (5.56)	5.37 (5.27)	7.66 (4.57)	6.58 (4.27)	5.11 (3.93)	5.1 (3.94)	2.15 (3.38)	2.95 (3.18)	42.44 (38.91)
Paphos	0.56 (1.18)	0.42 (1.35)	1.39 (1.28)	0.42 (1.16)	0.70 (1.17)	1.12 (1.15)	0.56 (1.11)	0.28 (1.03)	0.14 (1.07)	5.59 (10.50)

Table A3. Percentage of participants by gender. Survey sample vs Cyprus census 2019 (in parenthesis).

	male	female	total
Famagusta	3.68 (2.76)	1.91 (2.79)	5.59 (5.55)
Larnaca	6.99 (8.34)	4.57 (8.70)	11.56 (17.01)
Limassol	19.06 (13.52)	15.76 (14.48)	34.82 (28.00)
Nicosia	26.43 (18.83)	16.01 (20.08)	42.44 (38.91)
Paphos	4.19 (5.19)	1.40 (5.32)	5.59 (10.50)

Table A4. T-test for age groups and gender (survey sample vs Cyprus census 2019)

	age group									gender	
	20 - 24	**25 - 29**	**30 - 34**	**35 - 39**	**40 - 44**	**45 - 49**	**50 - 54**	**55 - 59**	**60 - 64**	**male**	**female**
p-value	0.394	0.512	0.774	0.494	0.485	0.799	0.935	0.293	0.594	0.675	0.620

Table A5. T-test for age groups and gender by district (survey sample vs Cyprus census 2019)

	Famagusta	Larnaca	Limassol	Nicosia	Paphos
p-value (gender)	0.983	0.155	0.186	0.768	0.221
p-value (age)	0.967	0.068	0.137	0.551	0.001

References

Barbosa, H., Barthelemy, M., Ghoshal, G., James, C. R., Lenormand, M., Louail, T., Menezes, R., Ramasco, J. J., Simini, F., & Tomasini, M. (2018). Human mobility: Models and applications. *Physics Reports*, *734*, 1–74. https://doi.org/10.1016/j.physrep.2018.01.001

Bhat, C. R., & Koppelman, F. S. (1999). Activity-Based Modeling of Travel Demand. In R. W. Hall (Ed.), *Handbook of Transportation Science* (Vol. 23, pp. 35–61). Springer US. https://doi.org/10.1007/978-1-4615-5203-1_3

Boccaletti, S., Bianconi, G., Criado, R., Del Genio, C. I., Gómez-Gardeñes, J., Romance, M., Sendiña-Nadal, I., Wang, Z., & Zanin, M. (2014). The structure and dynamics of multilayer networks. *Physics Reports*, *544*(1), 1–122. https://doi.org/10.1016/j.physrep.2014.07.001

CEU. MOVE., Univ. Eiffel., TRT., Panteia., GDCC., & STRATEC. (2022). *Study on new mobility patterns in European cities: Final report. Task A, EU wide passenger mobility survey.* Publications Office. https://data.europa.eu/doi/10.2832/728583

European Commission. (2014). *Special Eurobarometer 406: Attitudes of Europeans towards urban mobility* (Version v1.00) [Dataset]. http://data.europa.eu/88u/dataset/S1110_79_4_406

European Commission. (2015). *Special Eurobarometer 420: Passenger Rights* (Version v1.00) [Dataset]. http://data.europa.eu/88u/dataset/S2011_82_1_420

Fabbri, G., Federico, S., Fiaschi, D., & Gozzi, F. (2024). Mobility decisions, economic dynamics and epidemic. *Economic Theory*, *77*(1–2), 495–531. https://doi.org/10.1007/s00199-023-01485-1

Fayad, P., Hadjipetrou, S., Leventis, G., Kavroudakis, D., & Kyriakidis, P. (2023). Designing an Agent-Based Model for a City-Level Simulation of COVID-19 Spread in Cyprus: *Proceedings of the 13th International Conference on Simulation and Modeling Methodologies, Technologies and Applications*, 218–224. https://doi.org/10.5220/0012054000003546

Gallotti, R., & Barthelemy, M. (2014). Anatomy and efficiency of urban multimodal mobility. *Scientific Reports*, *4*(1), 6911. https://doi.org/10.1038/srep06911

González, M. C., Hidalgo, C. A., & Barabási, A.-L. (2008). Understanding individual human mobility patterns. *Nature*, *453*(7196), 779–782. https://doi.org/10.1038/nature06958

Hanson, S. (2005). Perspectives on the geographic stability and mobility of people in cities. *Proceedings of the National Academy of Sciences*, *102*(43), 15301–15306. https://doi.org/10.1073/pnas.0507309102

Hanson, S., & Huff, O. J. (1988). Systematic variability in repetitious travel. *Transportation*, *15*(1–2). https://doi.org/10.1007/BF00167983

Hunecke, M. (2009). *ADD HOME. Mobility Management for housing areas—From car-dependency to free choice*. https://trimis.ec.europa.eu/project/mobility-management-housing-areas-car-dependency-free-choice

Kitamura, R., Chen, C., Pendyala, R. M., & Narayanan, R. (2000). Micro-simulation of daily activity-travel patterns for travel demand forecasting. *Transportation*, *27*(1), 25–51. https://doi.org/10.1023/A:1005259324588

Kivela, M., Arenas, A., Barthelemy, M., Gleeson, J. P., Moreno, Y., & Porter, M. A. (2014). Multilayer networks. *Journal of Complex Networks*, *2*(3), 203–271. https://doi.org/10.1093/comnet/cnu016

Kleinberg, J. (2007). The wireless epidemic. *Nature*, *449*(7160), 287–288. https://doi.org/10.1038/449287a

Kyriakidis, P., Kavroudakis, D., Fayad, P., Hadjipetrou, S., Leventis, G., & Papakonstantinou, A. (2021). Promoting the adoption of agent-based modelling for synergistic interventions and decision-making during pandemic outbreaks. *AGILE: GIScience Series*, *2*, 1–5. https://doi.org/10.5194/agile-giss-2-44-2021

Lessani, M. N., Li, Z., Jing, F., Qiao, S., Zhang, J., Olatosi, B., & Li, X. (2023). Human mobility and the infectious disease transmission: A systematic review. *Geo-Spatial Information Science*, 1–28. https://doi.org/10.1080/10095020.2023.2275619

Levinson, D., & Wu, Y. (2005). The rational locator reexamined: Are travel times still stable? *Transportation*, *32*(2), 187–202. https://doi.org/10.1007/s11116-004-5507-4

Liang, X., Zhao, J., Dong, L., & Xu, K. (2013). Unraveling the origin of exponential law in intra-urban human mobility. *Scientific Reports*, *3*(1), 2983. https://doi.org/10.1038/srep02983

Litmeyer, M.-L., Gareis, P., Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR), Germany, Hennemann, S., & Department of Geography, Justus Liebig University Giessen, Gießen, Germany. (2023). Comparing student mobility pattern models. *European Journal of Geography*, *14*(1), 21–34. https://doi.org/10.48088/ejg.m.lit.14.1.21.34

Marchetti, C. (1994). Anthropological invariants in travel behavior. *Technological Forecasting and Social Change*, *47*(1), 75–88. https://doi.org/10.1016/0040-1625(94)90041-8

Nicolaides, C., Cueto-Felgueroso, L., González, M. C., & Juanes, R. (2012). A Metric of Influential Spreading during Contagion Dynamics through the Air Transportation Network. *PLoS ONE*, *7*(7), e40961. https://doi.org/10.1371/journal.pone.0040961

Palmer, J. R. B., Espenshade, T. J., Bartumeus, F., Chung, C. Y., Ozgencil, N. E., & Li, K. (2013). New Approaches to Human Mobility: Using Mobile Phones for Demographic Research. *Demography*, *50*(3), 1105–1128. https://doi.org/10.1007/s13524-012-0175-z

Pillai, A. N., Toh, K. B., Perdomo, D., Bhargava, S., Stoltzfus, A., Longini, I. M., Pearson, C. A. B., & Hladish, T. J. (2024). Agent-based modeling of the COVID-19 pandemic in Florida. *Epidemics*, *47*, 100774. https://doi.org/10.1016/j.epidem.2024.100774

Republic of Cyprus, Statistical Service. (2019). *Census of Population and Housing* [Dataset]. https://cystatdb.cystat.gov.cy/pxweb/en.

Rhee, I., Shin, M., Hong, S., Lee, K., & Chong, S. (2008). On the Levy-Walk Nature of Human Mobility. *IEEE INFOCOM 2008 - The 27th Conference on Computer Communications*, 924–932. https://doi.org/10.1109/INFOCOM.2008.145

Schlich, R., & Axhausen, K. W. (2003). Habitual travel behaviour: Evidence from a six-week travel diary. *Transportation*, *30*(1), 13–36. https://doi.org/10.1023/A:1021230507071

Schneider, C. M., Belik, V., Couronné, T., Smoreda, Z., & González, M. C. (2013). Unravelling daily human mobility motifs. *Journal of The Royal Society Interface*, *10*(84), 20130246. https://doi.org/10.1098/rsif.2013.0246

Simini, F., González, M. C., Maritan, A., & Barabási, A.-L. (2012). A universal model for mobility and migration patterns. *Nature*, *484*(7392), 96–100. https://doi.org/10.1038/nature10856

Statistical service of the Republic of Cyprus. (2010). *Short distance passenger mobility survey 2009*. Statistical Service of Cyprus. https://library.cystat.gov.cy/Documents/Publication/PASSENGER_MOBILITY_SURVEY09-120810.pdf

Ukkusuri, S. V., Mathew, T. V., & Waller, S. T. (2007). Robust Transportation Network Design Under Demand Uncertainty. *Computer-Aided Civil and Infrastructure Engineering*, *22*(1), 6–18. https://doi.org/10.1111/j.1467-8667.2006.00465.x

Varga, L., Kovács, A., Tóth, G., Papp, I., & Néda, Z. (2016). Further We Travel the Faster We Go. *PLOS ONE*, *11*(2), e0148913. https://doi.org/10.1371/journal.pone.0148913

Vorel, J. (2023). Strengths and weaknesses of the micro-simulation approach to analysis of residential mobility. *European Journal of Geography*, *6*(2), 69–84. https://www.eurogeojournal.eu/index.php/egj/article/view/415

Zehavi, Y. (1977). *The" UMOT" Model*. Urban Projects Department [of] the World Bank.

https://doi.org/10.48088/ejg.p.fay.15.4.305.318